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Proposed National Strategies for the Prevention of Leading Work – Related Diseases and Injuries

• Severe Occupational Traumatic Injuries •

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

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Proposed National Strategy for the Prevention of Severe Occupational Traumatic Injuries

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Introduction

This document, *A Proposed National Strategy for the Prevention of Severe Occupational Traumatic Injuries*, summarizes what actions need to be taken to prevent severe occupational traumatic injuries. It was developed in 1985 at a conference sponsored by the National Institute for Occupational Safety and Health (NIOSH) and The Association of Schools of Public Health (ASPH), which brought together over 50 expert panelists and 450 other occupational safety and health professionals.

In addition to the strategy for severe occupational traumatic injuries, NIOSH and ASPH have published strategies for the other nine leading occupational diseases and injuries: occupational lung diseases, musculoskeletal injuries, occupational cancers, occupational cardiovascular diseases, disorders of reproduction, neurotoxic disorders, noise-induced hearing loss, dermatological conditions and psychological disorders.

The proposed strategies were originally published in a two volume set, *Proposed National Strategies for the Prevention of Leading Work Related Diseases and Injuries, Part 1 and Part 2*. These proposed strategies are not to be considered as final statements of policy of NIOSH, The Association of Schools of Public Health, or of any agency or individual who was involved. Hopefully, they will be used in the quest to prevent disease and injury in the workplace.

To learn of the availability of the complete texts of Part 1 and Part 2, or to obtain additional copies of this or other Strategies, contact NIOSH Publications, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Telephone (513) 533-8287.

A Proposed National Strategy for the Prevention of Severe Occupational Traumatic Injuries

I. Severe Occupational Traumatic Injuries: Problems and Goals

Severe occupational traumatic injuries include serious, often disabling injuries such as amputations, fractures, severe lacerations, eye losses, acute poisonings, and burns. Worker deaths that are immediate, and without a preceding illness, are often the result of severe trauma incurred on the job.

Control of severe occupational traumatic injuries is not possible without a concerted effort by government, academia, private business, and labor. A control strategy that is national in scope must reflect a full spectrum of activities, not only emphasizing information dissemination and implementation of countermeasures but also including injury surveillance and analytical research. Therefore, the recommendations in this report represent not only what can be practically done today but also what should be done in the future. Embodied in these recommendations is a preliminary national strategy that may evolve as more is learned about the etiology and prevention of traumatic injuries and as more individuals and organizations make contributions to the effort.

II. Scope of the National Problem

Severe occupational traumatic injuries (including injuries associated with work-related motor vehicle accidents) pose a continuing and perhaps the major threat to the health and well-being of American workers. The National Institute for Occupational Safety and Health (NIOSH) estimates that at least 10 million persons suffer traumatic injuries on the job each year. About 30 percent (3 million) of these injuries are severe, and at least 10,000 are fatal. Analysis of potential life lost from various causes indicates that "accidents and adverse effects" are the leading cause of loss of potential productive years of life in this country. Occupational trauma is second only to motor vehicle accidents as a reported cause of unintentional death in the United States.

Occupational injuries, of which severe traumatic injuries constitute one of the important components, resulted in 80 million lost workdays in 1983. That same year, occupational injuries cost the United States an estimated $33.4 billion in direct costs (e.g., wage losses, insurance administrative costs, and medical costs) and indirect costs (e.g., time lost by other than injured workers, and administrative costs associated with accident investigation and reporting). This figure may grossly underestimate the extent of total costs to industry and to society at large resulting from occupational injuries and cannot begin to describe the immeasurable toll in human suffering.

National Safety Council estimates show declining rates of occupational fatalities and disabling injuries since the early 1970s, partly as a consequence of a growing workforce. However, the actual number of fatalities has declined slowly and the number of disabling injuries has remained essentially unchanged since 1945.

III. Amenability to Intervention

Several techniques and methods are available to prevent and reduce the severity of traumatic injuries. Traditional approaches include removing the hazard, placing barriers between the hazard and the worker (including the use of personal protective equipment), pre-employment screening to prevent assignment of particularly susceptible individuals (e.g., those incapable of performing the tasks or sustaining the stresses imposed by the tasks), job hazard analysis, improved job and tool design, compliance with regulatory and consensus standards, and training the worker to avoid the hazard. Evidence shows that application of traditional trauma prevention methods by knowledgeable professionals in a positive management environment reduces occupational injuries.

A dual approach is proposed to reduce the burden of such job injuries on the workforce, the economy, and the population of the country.

A. Immediate actions can be taken by interested groups and individuals based on prudent, carefully considered options for trauma prevention programs. These actions involve implementation of already developed and accepted policies and practices to reduce injuries within the context of positive, safety-minded management. Actions that can improve awareness and control of hazards include training, compliance with existing regulatory and consensus standards, better ergonomic design of equipment and jobs, early identification and recognition of emerging hazards, upgraded education of safety and health professionals, engineers, managers, and workers, and targeted, short-term injury control research.

B. For the long term, a major effort must be made to more thoroughly describe and study occupational injury incidents and to use the most rigorous methods of science available. Although present interventions are valuable in reducing workplace injury, scientific study is necessary because occupational "safety" is a set of control technologies (e.g., engineering, personal protective equipment, and monitoring) and administrative techniques (e.g., training, written policies, safe work practices) that have not been rigorously tested and validated. As an underdeveloped science, occupational trauma control needs research using the scientific methods that have contributed greater knowledge and prevention efforts in related health and injury fields.

One set of scientific methods, known collectively as epidemiology, has received increasing attention among trauma control professionals. Epidemiologic techniques can help those interested in reducing the incidence and severity of occupational trauma to see more clearly the scope of the problem and the complex relationships among the causal factors operating in the working environment.

IV. Epidemiology: Charting the Course

Epidemiology is a discipline applied to the practice of preventive medicine and public health. Use of epidemiology to evaluate the incidence of traumatic occupational injuries has tremendous potential because these injuries, like chronic and infectious diseases, seem to result from the interaction of a susceptible host and one or more etiologic agents within a particular environment. Furthermore, precedents have been established for the successful application of epidemiologic methods to evaluate injury etiology. For example, epidemiology has been used to assess the association of alcohol with automobile fatalities, the occurrence of falls and poisonings in residential buildings, the incidence of occupational and nonoccupational burn injuries, the factors associated with recreational injuries, and the success of various strategies for survival in disasters.

Epidemiology may serve as a common thread associated with the identification, evaluation, and control activities necessary for the prevention of traumatic injuries. Initially, descriptive epidemiology (e.g., surveillance and cross-sectional studies) is needed to *identify* high-risk exposures and factors. This identification will allow for the generation of scientific hypotheses about causation. Next, analytic epidemiology (e.g., cohort and case-comparison studies) can test the validity of these hypotheses. This analysis will allow for the *evaluation* of potential risk factors and exposures and for suggestions of appropriate control strategies. After designating specific control strategies, epidemiologic field and clinical studies can be used to *evaluate* the efficacy of these strategies. Appropriate surveillance activities can then assess progress in the *control* of traumatic injuries based on implementation of specific preventive strategies.

Surveillance appears to be a key epidemiologic component in the prevention of occupational traumatic injury. This component must be viewed as both an initial activity designed to establish baseline information, and as a continuing activity designed to generate dynamic profiles characterizing how the national occupational safety experience is changing, and in some instances, why the change has occurred.

Most workplace accidents occur as a result of the coincidence of separate cause-effect sequences, each influenced by multiple factors or stressors. In formulating actions aimed at controlling severe occupational trauma, consideration must be given to the risk factors associated with the following workplace components: the *task*, the working *environment*, the *machine*, and the *worker*. Each set of risk factors represents an area in need of scientific study in the multidisciplinary effort to mitigate occupational trauma through research.

All too often, however, researchers focus on only one of these aspects without considering the total workplace. Modifications in any component of this complex system must be carefully evaluated with a view toward effects on the total system. Traumatic injury research must be specific and painstaking, yet must reflect a balanced, systems-oriented perspective so that the findings will be adaptable to employers' needs; employers, after all, must manage these complex industrial sys-

tems. Indeed, the importance of management's role in the prevention of occupational traumatic injuries cannot be overemphasized, and providing managers with valid, useful information is a must.

The present discussion follows the order of the workplace components outlined above. It addresses those risk factors of the workplace components for which we now have sufficient information to implement effective intervention strategies and then examines those risk factors for which critical knowledge gaps must still be explored before meaningful intervention can begin.

V. Prevention Components: What We Know and Can Implement Now

Energy release is associated with the interaction of task, environment, machine, and worker. Traumatic injuries may result from employee exposures to unexpected releases of energy in amounts that the human body cannot tolerate. The release of energy that results in harm is usually due to lack of management control or improper management of the working environment.

Programs established to reduce occupational traumatic injuries must be formulated and implemented by management. Management policies, procedures, and supervision dictate how effective injury prevention efforts will be.

Evaluation of effective safety programs has established that the most important component of such programs is management's commitment from the top down. Such programs contain basic elements such as safety policy statements, assignment of safety responsibilities through all levels of management, establishment of safety performance accountability, identification of hazards in the workplace, establishment of control measures (in accordance with regulatory and consensus safety standards), employee involvement in hazard identification and control, safety training for employees, accident investigation policies, and planning for emergencies. Management accepts the responsibility of tying these elements together so that the nucleus of the industrial system (task, environment, machine, worker) can function with the least possible unforeseen interruption.

A. Task-Oriented Strategies — Modifying the Job

Failure to follow established standards for work practice is considered responsible for a large portion of occupational injuries and deaths. Reduced numbers of injuries and deaths can result from the increased use of effective work practices.

Safe work practices exist for many hazardous operations. Control methods exist for all energy sources found in United States workplaces. The extent of occupational injury incidence indicates that employers either are unaware of the hazards inherent in their operations or the appropriate control strategies, or are unable or unwilling to effectively implement those strategies. This indicates weaknesses in dissemination and employers' safety programs.

Employers can use job hazard analysis as a technique to identify job hazards and appropriate preventive countermeasures. All job tasks should be analyzed individually from the perspective of identifying obvious, anticipated, or foreseeable hazards. Of course, not all hazards are immediately obvious or can be reasonably foreseen. Programs should include timely reassessment or monitoring activities

to detect previously unknown or undetected hazards. Appropriate preventive countermeasures can then be applied to eliminate or reduce risk to the worker from those hazards, including modifications to the task. Job hazard analysis is an important approach because hazards can often be anticipated. This is clearly better than reacting to a hazard after a traumatic event.

Although the effectiveness of known countermeasures has not been determined, increased implementation of appropriate safe work practices and procedures is anticipated to have a major impact on reducing national injury and death rates.

B. Environment-Oriented Strategies: Changing the Work Environment

The working environment includes the physical environment, the psychosocial environment, and the political/economic environment. Of these, the physical environment is the most amenable to immediate action. The impact of broader environmental issues on the incidence of traumatic injuries must be carefully studied.

The influence of factors in the physical environment (e.g., layout and condition of the facility, illumination, temperature, relative humidity, noise, vibration) on the productivity and safe performance of occupational tasks has been studied for more than 50 years. Based on consensus and standard industry practice, guidelines have been developed for the control of these potential physical stressors to minimize direct bodily insult or trauma. Compliance with these guidelines can help to reduce the risk of occupational injury. The principal obstacles to wider application of known controls are inadequate information dissemination and inadequate safety program management. Cost constraints can also inhibit adoption of necessary environmental controls.

Many private sector organizations have developed safety and health prevention programs that have demonstrated trauma reductions and worker health enhancement. Means should be sought through trade associations, the National Safety Council, labor organizations, insurance organizations, and others to influence other companies to incorporate the essential aspects of such effective programs into programs of their own.

C. Machine-Oriented Strategies: The Safe Machine

Machines are assemblages of parts designed to transmit or modify the application of power, force, or motion to perform predetermined functions. Workers use a wide variety of machines to be more productive. The various forms of energy associated with machines, if not adequately controlled, can result in traumatic injuries to workers. Numerous measures known to control this release of energy should be applied in the workplace.

1. Standards

Regulatory and consensus standards now exist to protect workers in various ways from interaction with specific industrial machines. Many of these protective measures propose the placement of barriers between the worker and recognized hazardous energy sources associated with the machinery. These barriers range from guards placed on moving pieces of machinery to protective equipment worn by workers. References to recognized controls can be found in the occupational safety and health standards and appropriate publica-

tions by consensus organizations such as the American National Standards Institute.

2. Manufacturer Safeguards

Manufacturers are continually seeking to build a better "mouse trap." State-of-the-art technology can be geared toward producing a safer and a more functional machine. Employers should take advantage of proven developments when procuring machines. At a minimum, procurement procedures should require that newly purchased machinery meet an appropriate currently recognized regulatory and consensus standards.

D. Human-Oriented Strategies — Managing the Worker

The most complex and the least measurable component of the task/environment/machine/worker model is the worker. To some safety practitioners, a worker is characterized by the behaviors exhibited in the workplace that influence system output. Many of these practitioners believe that human behavior is totally unpredictable and uncontrollable. To others, a worker is a set of abstracted attributes — occupation, sex, age, part of body injured, etc. Still others see the worker as the sum of the effects produced by the working environment — stress, injury or illness, disability, fatigue, motivation, productivity or nonproductivity, absenteeism, etc. To some, a worker is a set of psychologic and physiologic capabilities and limitations. Perhaps the most successful practitioners in the area of traumatic injury control see the worker as their most valuable resource, to be carefully nurtured and protected.

Of course, human beings are all of these characteristics and more. Thus, a variety of people need to be involved in the study of tasks, working environments, machines, and workers to comprehend the worker as both an entity and a functioning part of larger systems. Individuals with training and experience in behavioral science, ergonomics, biomechanics, biomedical engineering, and related scientific and engineering fields are needed to apply the control of occupational traumatic injury and to provide critical knowledge regarding the human components of industrial systems.

1. Training

Training is an integral component of trauma prevention. From the earliest days of childhood, we are taught to look both ways before crossing the street or, more recently, to buckle our seat belts after getting into a car. As a result, some of us do these things automatically. However, most of us are not trained early in life for the vocation we may have as adults. As a consequence, we get a job and learn firsthand about its inherent dangers.

Strong evidence indicates that knowledgeable, well-trained workers can avoid injury while performing hazardous work, and that untrained, uninformed workers can be injured under almost risk-free conditions. NIOSH field investigations of fatalities associated with confined spaces have shown that lack of awareness or recognition of the hazards, by both managers and workers, and lack of training in hazard awareness may be major factors contributing to occupational fatalities. Government agencies, notably the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA), have addressed the need for training

through standards and educational resources. Although these various regulatory agencies require training, the degree and level of training are seldom specified, resulting in extreme differences in the application of training among similar industries or within the same industry. Also, existing regulations may not cover certain high-risk groups at all, and therefore even minimal training in hazard awareness and control is not provided.

A key activity in the development of training programs is identification of training components that combine to produce a successful program. The establishment of a model training program could ensure that a wider population of workers is provided more uniform and basic training in hazard awareness and trauma control. Of course, such models would require tailoring to meet the specific needs of particular industries, worker populations, and facilities.

Employees in such high-risk occupations as punch press operators, crane operators, industrial truck operators, over-the-road truck drivers, agricultural workers, and workers in many occupations who are exposed to the hazards inherent in confined work spaces, trenches, and chemical handling tasks should be primary targets for such training.

2. Hazard Communication

Effective communication through information dissemination, education, and training could have an immediate positive impact on the incidence of work-related injuries and deaths. Certain workplace energy hazards, or intrinsically dangerous operations such as confined space entry and excavations work, might be effectively mitigated by implementing a program comparable to the OSHA hazard communication standard addressing workplace chemicals (29 CFR 1910.1200). Requiring employers to provide workers with information and training on particularly hazardous aspects of their work could substantially reduce traumatic injuries associated with those hazards.

3. Known Interventions

When surveillance, particularly at the organizational level, identifies the high incidence of a type of injury associated with a high risk industry, occupation, or task (e.g., foot injuries in a foundry), known intervention methods (e.g., protective footwear) should be applied. Training and reinforcing the worker to be aware of the high probability of traumatic injuries are important components of an intervention program. By providing the worker with the tools and knowledge to avoid traumatic injuries, intervention strategies serve as effective models toward prevention efforts.

4. Rehabilitation

Rehabilitation services, available through several programs, provide retraining in different occupations for workers suffering permanent disabling injuries at work. Such programs will increase in importance with the decrease in the number of younger workers entering the workforce and the national trend toward an older workforce.

VI. Prevention Components: What Knowledge Do We Need

Because the basic elements of effective safety programs are known, management can operate such programs efficiently and profitably to reduce occupational injuries. However, to progress in this endeavor, management must have access to cost-effective, scientifically proven methods that reduce injuries, and it must have more information to help allocate limited resources for occupational safety programs. Information valuable to management would include:

- Risks presented in measurable terms
- Methods developed to assess workplace hazards and controls
- Criteria to select workers for specific task, environment, machine, and worker interrelationships
- Components of effective safety training programs
- Means of assessing worker stress indicators in relation to safe job performance
- Access to proven safe work practices and procedures

A. Task-Oriented Strategies—Modifying the Job

Scientific validation is needed for the established countermeasures relating to task procedures. In general, established countermeasures represent the best judgment of the trauma control community, but they have not been demonstrated through rigorous scientific studies to be effective. Recommended procedures for specific tasks would certainly be more readily accepted and used if they were demonstrably effective in reducing worker injury and death. In addition, measurement of the effectiveness of a particular countermeasure would be invaluable in demonstrating the cost effectiveness to employers, managers, and the public in general.

B. Environment-Oriented Strategies—Changing the Work Environment

1. Physical Environment

Although guidelines are available for controlling harmful environmental agents, the influence of these agents on the incidence of occupational traumatic injuries has not been defined. For example, some initial investigations of the potential detrimental effect of such agents on optimal safety performance have been conducted, but much research lies ahead.

2. Psychosocial Environment

A major impediment to traumatic injury control is the notion, prevalent in the general population, that "accidental" injuries are not preventable. In addition, two fundamental components of the national psychology—risk-taking behavior and the perception of personal immunity from injury—extend quite naturally into the working environment. The psychosocial environment, as it influences the perception of hazard and risk taking, is amenable to modification through the techniques of advertising, information dissemination, and social interaction. For example, the decline in cigarette smoking in the United

States can be attributed in large part to two closely related factors: 1) the shift from media saturation with "pro-smoking" advertising toward a more balanced media presentation of smoking (with some media legally prohibited from "pro-smoking" advertisements) and 2) the evolution from an absence of clear scientific and clinical evidence to a flood of information propelled by the Surgeon General's anti-smoking campaign.

The approach of environmental modification, including efforts to influence coverage by the mass media, should be exploited through a serious concerted effort. Messages must be specific, supportable, and persuasive. General themes such as "safety first" or "think safety" have been minimally effective, if at all. Clearly, modifying public perception to the degree that 1) traumatic injuries are no longer regarded as resulting from "chance" occurrences beyond human control, and 2) the large number of injuries and deaths attributed to work-related trauma are no longer morally acceptable, will represent a quantum leap for a national preventive effort.

3. Political/Economic Environment

a. Changing Work Force

The composition of the work force in the United States has changed dramatically over the past 3 decades. Some industrial sectors are growing much faster than others. For example, from 1950 to 1980 the rates of increase in employment ranged from 14 percent in mining, 28 percent in transportation, and 33 percent in manufacturing, to 170 percent in government, 173 percent in finance, and 234 percent in the service sector.

Fundamental shifts in national employment patterns have continued into the 1980s, such as rapidly increasing numbers of women and increasing participation of certain ethnic minority groups in the work force. Other changing patterns are likely to continue, with some estimates suggesting that less than 10 percent of the national work force will be blue-collar workers by the mid-1990s. The changing economic environment characterized by the exportation of blue-collar jobs and polarization of the work force into professional, technical, managerial, and service occupations has not been fully accommodated by a corresponding change in the thrust of safety program application.

Remodernization, associated with increased use of computers and automated or programmable machines (robots), is rapidly expanding. These factors create a unique and dynamic environment that challenges proponents of traumatic injury prevention and control to anticipate change. Development of positive prevention-oriented planning must occur in parallel with industrial change, not follow it.

b. Emerging Technology

We must begin immediately to apply to problems of the future those organizational and technical lessons learned at such a high cost in the past. After all, our failure to consider the potential hazards of the "new" technologies of yesteryear (e.g., mass production, basic chemicals, and iron and steel) allowed an exorbitant toll in unnecessary injuries and deaths through the years, even to this day. Newly emerging technologies such as

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genetic engineering, robotics, computers, and space commercialization are prime candidates for study. To address potential emerging problems will require:

- The widest possible application of existing safety technology
- Development of research programs for safety technology at the centers of the emerging technologies
- Specialized surveillance programs keyed to anticipated problem areas

c. New Hazard Control Techniques

Innovation in techniques for the recognition, analysis, and mitigation of hazards and the management of risk is slowly emerging from extensions of econometrics, policy analysis, reliability engineering, and operations research. However, no formal body of information, discipline, or center of excellence now exists to nurture these new approaches to the safety question. Consideration should be given to establishing a center for research into the non mechanistic arena of safety.

d. Economic Issues

In 1982, $22.5 billion were paid for workers' compensation insurance coverage or approximately $275 per worker covered. Yet the National Safety Council estimates that all workers would need to produce additional goods or services with a value of $810 per worker to offset the cost of worker injuries. This finding may indicate that compensation insurance rates are not high enough to provide a positive incentive for reducing occupational trauma. In addition, the "liability proofing" that compensation coverage conveys to the employer may provide a further disincentive to prevention programs. Nonetheless, the present compensation system for occupational injuries is important to the nation's working men and women and, although perhaps not ideal, it should be maintained and strengthened.

The economic incentives and disincentives associated with workers' compensation are being carefully analyzed by the insurance industry, private economics-oriented research organizations, and governmental components. Analyses have been undertaken to determine the savings that can be realized through emphasis on prevention, but much work is needed in this area. The emergence of the newly created Workers' Compensation Research Institute (WCRI) is evidence of the increasing attention being focused on understanding the complex economic forces that influence occupational traumatic injury and fatality incidence and the efforts to control these outcomes.

Insurance rates are increasing, the work force is maturing as fewer and fewer young people enter the job market, and labor shortages in key occupations can be anticipated. These influences will require a more enlightened approach to management commitments to worker safety. It is encouraging that many employers are beginning to recognize the negative economic impact that traumatic injuries have in lost workdays, high medical costs, loss of productivity, and increases in insurance rates and liability

claims. Programs should be undertaken to identify the true costs of injuries and fatalities and to more clearly show the economic consequences of trauma. For greater impact, these findings should be specific for industry and occupation; and the results should be widely disseminated.

Furthermore, the human element of this issue of occupational trauma insurance has dimensions beyond just compensation insurance. The cost of not only compensation insurance but of disability and product-liability insurance must be considered as well. From the designer's perspective, liability—especially third party liability—appears to be the driving force. This may operate as a negative force by pushing up disability costs for trauma and related compensation. The cost relationships between these competing insurance elements, whether positive or negative, have never been examined from the perspective of occupational trauma. Studies of this should be undertaken and recommendations made for changes as appropriate.

C. Machine-Oriented Strategies: The Safe Machine

Present concepts of safe machines generally involve installation of barriers or enclosures around hazardous machine parts to prevent accidental worker contact. Although these concepts seem to be effective, employees working with or around machines still experience numerous injuries. This finding implies that several potential problems exist with either the barrier concept or the lack of knowledge of other factors contributing to injuries. Moreover, the large body of voluntary consensus standards for machinery should be reevaluated and refined where appropriate, and wider compliance should be promoted. Establishing and including the current technical basis for each standard as part of the guidelines would enhance user understanding and acceptance and would facilitate necessary revision.

Scientific studies must be performed to determine the efficacy of barrier methods and to provide managers with expected rates of injury reduction through application of these methods. Motivational and behavioral elements, such as piece wage rates, should be evaluated with the associated injury problem.

Machines are being designed to operate faster and with greater reliability in quality control of the product. Production systems are becoming more automated with management goals of totally automated production lines, and new technologic uses of energy are being applied within these systems. These design concepts should take into account safe methods of feeding and removing stock materials and the stressors on workers to keep the automated system running. This should lead to development of controls that minimize human (both manager and worker) error and limit the speed and travel of machines within human reaction tolerances.

D. Human-Oriented Strategies: Managing the Worker

1. Age and Traumatic Injuries

America's population is aging. By the year 2040, an estimated 68.4 million people—one American in four—will be over the age of 65. The 18- to 24-year-old work force, which has traditionally evidenced the highest traumatic injury incidence rates, is declining in size. As the work force gets older, age-

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related risk factors for traumatic injuries increase. Older workers give up speed for accuracy, are slower to react in quickly changing situations, and have reduced range of motion compared with their younger counterparts. In addition, they may have less tolerance for changing environmental conditions, such as extreme heat or cold. Although older workers are often considered more cautious and even more productive than their younger counterparts, the decreasing influx of young workers may force older workers to remain in high-risk jobs or activities longer. Therefore, larger numbers of injuries to older workers seem likely, not so much because of diminished physical and sensory capabilities, but because of increased exposure.

Given the changing age of the United States work force, employers have already begun to study ways to attract and keep younger workers. Careful planning will be necessary to reduce traumatic injuries with consideration of the risk characteristics of *both* young and older workers.

2. Training

As our economy changes from heavy industry to service, training will become more important, particularly as new and sophisticated equipment and systems are introduced into the workplace to increase productivity.

Training the worker is an art as well as a science. To master their jobs, and, as a result, to reduce their odds of incurring traumatic injuries, workers have basically been trained in four levels of technology: 1) the worker supplies power and control, such as using a box wrench to tighten a nut, 2) the tool supplies power and the worker controls it, such as using a hand-held power screw gun to drive in a screw, 3) both power and information are supplied, but the worker is in control, such as in a paper-making plant, and 4) power, control, and information are supplied in a self-monitoring system, and workers intervene only if something goes wrong, such as in a nuclear power plant or when an autopilot is activated in an airplane.

In many industrial processes technology is rapidly leaving levels one and two and moving toward levels three and four. Computer technology has made this possible at an accelerated rate. Training of workers and retraining of older workers have become issues that will be of greater importance in the future. Research is needed on the ability of workers to control entire systems and to provide quick, controlled, and reliable responses when problems arise.

The mere provision of training does not ensure that a traumatic event will not occur. The adequacy of training, retraining, and post-training policies and practices needs evaluation to determine appropriate prevention strategies for particular groups of workers in selected work settings. The need for retraining could be evaluated by analyzing surveillance data on the components of traumatic events or investigations of near misses.

3. Behavior

Human behavior and its relationship to safe work activity have received little if any research attention. Why do workers circumvent safety devices? Why do they attempt to rescue a fallen worker in a confined space only to die themselves in the rescue attempt? What outside workplace forces stimulate or mitigate such behavior? Such issues must be addressed in the context of

the current workplace. Practical techniques of positive reinforcement must be improved and applied for safe work practices.

a. Motivational Factors

Changes toward more service activities, the maturing of the work force, and the decline of the 18- to 24-year-old population have already stimulated major corporations to reexamine the factors that motivate workers. Such studies have focused on economic considerations, with workers hired and maintained on the basis of their motivation to produce. Some attention has been devoted to motivational issues, such as studies of different reinforcing strategies, which may be important to the reduction of trauma in the workplace. More such studies should be undertaken.

b. Employee Participation

In the future, reducing traumatic injuries will involve more group participation than it has in the past. Recently, quality circles, formed in the automobile industry to bring workers, unions, and management together to discuss work issues including safety, have proved to be extremely productive. However, the impact of such participative processes on worker safety has not been fully evaluated scientifically.

In automobile plants, workers have been aiding management in a smoother transition from one technology to another as manual materials handling and assembly give way to automated systems, such as robot material handlers and assemblers. Although the change in technology may reduce some traumatic injuries (e.g., amputations from power presses), impact or crushing fatalities may occur with robots. Therefore, management must initiate ways to enlist the interest and cooperation of workers so that the hazards inherent in new technologies can be fully understood more quickly. Appropriate controls can be developed and made available more rapidly if managers draw on the largest possible pool of expertise available, including workers. Safety researchers need to determine what intervention and prevention programs will be most effective in reducing and eliminating traumatic injuries in computer-mediated work processes.

c. Use and Abuse of Substances

The use and abuse of substances as a factor in highway trauma is well documented. Although the role of alcohol or drug abuse in the occupational setting is less well understood, use of these substances has been linked to such disasters as train derailments. Alcohol, controlled substances, physician-prescribed and self-prescribed medications are known to be used in the workplace, but the magnitude of the problem is largely unknown. Use of a single substance alone (e.g., alcohol) may result in trauma, or personal-use substances may combine with chemicals in the workplace (e.g., inhaled chlorinated hydrocarbons) to produce additive or synergistic effects that contribute to trauma-producing conditions. For example, the pharmacologic effect of a prescribed medication may be altered by a substance present in the working environment. If the effect is increased, it may manifest in an overdose; if the effect is decreased, it may deprive a worker of the needed benefits of medication. Either could contribute to a traumatic injury at or after work. Consistent with its mandate to conduct

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research, make recommendations, and train professionals regarding workplace hazards, NIOSH should continue to help those agencies that have specific responsibility for personal behavior and substance abuse by supplying them with technical information and by increasing their sensitivity to worker attitudes and needs.

d. Risk Taking

Risk taking is one of the basic human behavioral factors that made the United States the type of society it is today. We are accustomed to risk taking and are born and raised with the belief that it is the heart of the free enterprise system. Such a philosophy has permeated our society, lifestyles, and workplace. Risk-taking behavior in the workplace is not only recognized but rewarded, such as through piecework wage rates and time-to-complete incentives in the construction industry. This fundamental aspect should receive additional attention and should be modified where possible when it contributes to occupational trauma.

e. Lifestyle Changes

Major life events (e.g., the death of a spouse) are recognized as important health sentinels, but their impact on the risk of traumatic injury has not been systematically studied. Research should be initiated to evaluate whether major life events can increase the risk of occupational traumatic injury. A growing trend in industry is the availability of employee counselors, particularly in larger, well-established companies. Employee concerns may range from family to finances, work, or career mobility. These companies realize that the mental well-being of workers is important and that employees may need trained counselors to help them through crisis periods. Such a service may have an impact on reducing both intentional trauma such as suicide and homicide, and unintentional trauma such as accidental injury resulting directly from inattention.

4. Rehabilitation

Rehabilitation of severely injured workers, although clearly not a prevention technique per se (in terms of initial traumatic events), is a method of mitigating the severity of traumatic injuries by preventing unnecessarily prolonged disability, loss of income, and ultimately reduced quality of life. In addition, employers' rehabilitation programs can serve as evidence of management's commitment to employee well-being and can, therefore, lend credibility to other, more prevention-oriented aspects of a trauma control program. Current rehabilitation programs are expensive, and the value of such activities has yet to be fully assessed. Evaluations of rehabilitation programs from national, state, local, private sector, and personal perspectives should be conducted with a view toward enhancing the effectiveness of such programs.

One area requiring further research is the development of objective techniques for diagnosing traumatic injuries to specific body parts, in which neurologic and motor dysfunctions are assessed and the worker is given appropriate treatment. Essential considerations from a management standpoint include allowing sufficient time and ensuring mental, psychologic, and physical conditioning to prepare and integrate the worker's return to the workplace. Management should be aware that a gradual reconditioning work

period is needed before a worker can return to his potential. Research is needed on the system approach of industry, worker, health care, rehabilitation, return to work, and work adjustment.

VII. Recommendations

Two types of actions are recommended, immediate and long-term. The first set of recommendations can be implemented immediately based on the current state of knowledge and societal organization. The second set reflects the need to 1) scientifically investigate further the causal mechanisms underlying occupational trauma and the available potential control technologies, 2) reevaluate the structure of our existing national programs for addressing the problem of occupational trauma, and 3) assess economic benefits resulting from effective trauma intervention; i.e., a realistic focus on the savings.

A. What Can Be Done Now

1. Develop models of programs for successful occupational trauma prevention and encourage their implementation through a workplace-specific, self-evaluation approach.

   Generic components of successful programs for trauma prevention across a variety of industries have included strong management commitment, stable work force, high level of housekeeping and effective environmental quality, and effective training practices. Most employers who voluntarily seek ways to improve programs, such as adaptation of successful program components, are already committed to employee protection. An effort must be made to influence less committed employers to use available prevention tools.

   The self-evaluation approach has proven successful in specific industries where self-evaluation tools were keyed to industry-specific characteristics. Several important concepts are embodied in the recommendation: 1) the need to promote the anticipation of hazards through an analytical process, 2) the need to involve the work force in identifying hazards and developing or discriminating among existing controls to address hazards, and 3) the need to tailor self-evaluation tools to specific industrial settings, as demonstrated in the utilities and communications industries.

   Two important areas of consideration need to be emphasized: 1) making such self-evaluation procedures voluntary and exempt from punitive repercussions (when such models have been field-tested and validated, promulgation of standards may be feasible), and 2) focusing on two important groups:

   - High-risk industries identified through existing data systems and addressed in a priority-setting basis.
   - Specific worker populations that may be neglected in coverage by regulatory or statistical databases and may, on scrutiny, be high hazard groups; e.g., agricultural workers, truck drivers, small business employees, the self-employed.

2. Develop information centers for injury prevention technology.

   Information about hazard control problems and effective solutions must be

easily accessible to professionals for specific applications. For example, a case study format could be used to compile a source reference available in both "hard copy" and through "electronic access." Selection criteria should also be specified to ensure appropriate quality and technical validity.

In addition, existing information centers need to be broadened to include specific trauma-related data from epidemiologic studies, injury investigations, surveillance and other sources, such as anthropometric, biomechanical, forensic, and physiologic databases.

3. Promote the maximum use of machine guarding technology.

Maximum resources should be used to provide worker protection for all new or rebuilt single-purpose machines and power-transmission devices. All appropriate enforcement agencies are encouraged to use their resources and authority to ensure that appropriate safeguards are installed and used. Another approach would call for model purchase agreements including supplier certification of the presence of current state-of-the-art technology and use restrictions. Special emphasis should be given to mechanical power presses and point-of-operation guards. Whenever possible, guards should be an integral, non-removable part of the machine design to avoid confusion among users about the adequacy of the safeguards. Regulations or recommendations should be made only after clearly demonstrating that specific machines present a hazard, that state-of-the-art technology is available to provide adequate worker protection, and that safeguards will be compatible with the operations and maintenance of the machines and not introduce new worker hazards. Additional efforts should be directed toward producing engineering guides for safe use of multi-purpose machines and machine controls ensuring that warning signs are posted on or near all machines known to present traumatic injury hazards to workers.

4. Integrate the knowledge of traumatic injury control into educational curricula.

A national program should be developed and implemented to draw the attention of educational institutions, professional societies, accreditation bodies, state and local agencies, and others to the need for education and training to control acute trauma and disabling injuries. This program would promote course work in acute trauma prevention in the nation's educational institutions, including schools, colleges, and universities of vocational technology, education, business, engineering, architecture, public health, and medicine. Model program material would be developed for various educational levels ranging from high school to graduate school. Educational materials should be directed through accreditation programs, professional societies, and higher education administrators. Model curricula should include hazard communication, product liability, and control technology information. Other governmental and private programs should be encouraged to participate in the effort.

5. Develop a trauma control training model for specialists, managers, supervisors, and workers.

A model training program for use by all firms in meeting the minimum training requirements specified by regulatory agencies (MSHA and OSHA)

should address the basic elements of the hazard control process—recognition, evaluation, and control. The model should include the following elements:

- Techniques for hazard identification, evaluation, and control
- Methods for ranking hazards according to potential destructive consequences
- Guidelines for selecting training methods
- Materials to be included in presentation
- Methods for evaluating effectiveness of training
- Guidelines for post-training management actions and retraining

Particular concern should be given to worker motivational and behavioral changes and to ultimate distribution of completed programs. The training model should be adapted to the needs of trauma control specialists, managers, supervisors, and workers.

6. Expand occupational trauma research.

Efforts are essential to stimulate the traditional research communities in engineering, universities, and public health to address hazard identification, accident causation, and effective intervention/hazard control with specific funding, such as national grant programs for occupational injury prevention research. The need for interdisciplinary research initiatives in the area of traumatic injury research should be emphasized.

7. Re evaluate existing occupational consensus standards and codes.

Existing occupational consensus standards and codes must be re-evaluated with a view toward establishing a technical basis for each and, based thereon, appropriate revisions should be pursued. Many occupational standards, regulations, and engineering practices are based on consensus standards or codes and rarely reflect the technical rationale that supports the recommended practice. Therefore, the practitioners who must use such standards or codes have no basis of understanding. In addition, because the technical rationale does not exist, such standards or codes are extremely difficult to review as new information emerges.

8. Monitor product liability decisions.

Because outcomes of product liability litigation have a strong influence on product designers and suppliers, "liability proofing" often overshadows the need to design safe devices for use in the workplace. Occupationally related decisions on product liability should be monitored to identify potential increased risk to workers of traumatic injury. Findings should be disseminated to bodies responsible for consensus standards, regulatory agencies, employers, worker organizations, and related research organizations.

B. Longer Term Actions

1. Develop a national surveillance system for traumatic injuries.

Based on the current limitations of existing documentation and reporting systems for traumatic injury and the redundancies in these systems, it would be highly desirable to establish a single surveillance system that satisfies all regulatory, compensatory, litigation, and research requirements (including causative models). Such a system would relieve American employers and employees who are currently burdened with redundant criteria for reporting information that is often not efficiently and effectively collected, analyzed, and disseminated.

This reporting system for mortality and morbidity from injuries should cover all American workers, regardless of their occupation, the number of employees they work with, or the extent of associated disability. A model with optimal data elements in the system should be developed and tested to fulfill all current and anticipated uses of such data.

Data should include information on products (machines, tools, equipment) used in the workplace, such as identification of manufacturer and model; engineering controls used; personal protective equipment used; job title and tasks; worker characteristics, such as training, experience, and shift factors; compliance with standards; and location of accident.

Information should also include sufficient etiologic descriptions of the circumstances associated with injury incidence. All possible sources of information about injury cases should eventually be tapped, including hospital reports, medical examiner reports, and accident investigation reports. The system should also include denominator data of sufficient detail to assess worker risks of injury when combined with numerator data.

Design of the surveillance system should address the issues of confidentiality (e.g., privacy act requirements) and the consideration of whether the accident investigation data collected should be used for punitive action (introduction of information bias). For selected areas of specific interest, the system should allow further collection of specified information through followup of individual cases.

Although development of a single, comprehensive surveillance system that would satisfy a wide range of data requirements for traumatic injuries might be an ideal solution to the limitations and burdens inherent in existing systems, more practical interim efforts are possible. For example, existing systems might be effectively augmented to expand their value for researchers in traumatic injury control. At present, privacy acts have made some data sources largely unavailable to those studying traumatic injuries. Such sources might provide extensive and useful data if the sensitive information can be properly protected. Surveillance systems specific to industrial sectors and that support industry-specific research efforts might also be feasible (see recommendation #3 below). A variation of the comprehensive system outlined above might entail the collection of a small core of data on each severely injured worker, with mechanisms available to access other pertinent files or accomplish more in-depth sampling of particular types of injuries, agents, populations, or other factors.

2. Promote epidemiologic studies of traumatic injuries and prevention countermeasures.

   Epidemiologic methods should be used to study traumatic injuries and provide information about their incidence and prevention. Data from the national traumatic injury surveillance system can be used for case series and cross-sectional analyses to provide statistics describing the magnitude and characteristics of specific traumatic injuries. These analyses can also be used to generate hypotheses and set research and resource priorities. Analytic epidemiologic designs (cohort and case-control studies) should provide risk assessment of selected factors associated with injury incidence. Field trials should be conducted to evaluate the efficacy of specific prevention interventions.

   These applications of epidemiologic methods will minimize many current gaps in knowledge about traumatic injury incidence. For example, 1) traumatic injury statistics are often cited that are neither valid nor representative; 2) unsubstantiated conclusions are often made about factors (training, worker behavior, experience, supervision) that influence the risk of traumatic injury; 3) the feasibility and success of prevention countermeasures are either never evaluated or are subjectively supported.

3. Create industrial associations within each major industrial division for research on traumatic injuries.

   The continuing toll of occupational injuries and illnesses suggests that national programs established to ensure safe and healthful working conditions are not yielding the desired results. At least two primary reasons can be cited for existing programs not producing effective control measures:

   a. Developing controls and validating effectiveness scientifically require extensive resources not currently available.

   b. Personnel working within national programs lack sufficient familiarity with each specific industry to identify the specific problems and the practical solutions that would result in significant reductions of injury and illness.

   To help reduce these problems, a study is recommended to evaluate the possibility of organizing Industrial Traumatic Injury Research Associations for each major industrial division, as defined by the Standard Industrial Classification (SIC) Manual. These associations should be private, nonprofit entities, responsible for performing quality research approved by a tripartite research review board, and should not be for regulatory purposes. Management, labor, and state and federal governments should be equally represented in the administration of these associations. The Construction Safety Association of Ontario is an example of such an association.

   Alternative means of addressing research to specific groups might include a division along geographic lines. Indeed, some variances in occupational injury experience may be attributed to regional differences (e.g., geographic, climatic, and demographic). For example, the Occupational Health Program in the State of Washington shows not only an innovative approach to funding but also the level of cooperation possible among government, academia, industry, and labor.

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Existing national programs could be used to support the promulgation of occupational regulation, the development of scientific methods for research associations, and the generation of research tools that the associations could apply to problems identified in their specific industries or regions.

4. Examine the use and abuse of substances in the workplace.

The influence of substances on a worker's risk of incurring traumatic injury should be examined carefully through both personal use and workplace exposure, alone and in combination. Substances, medications, and chemicals that can increase the risk of traumatic injury should be identified, as should the workplaces where such substances may be encountered. Methods should be developed to screen workers for susceptibility to these substances and to provide warnings to prevent exposures. On-the-job testing of workers for illicit use of controlled substances has received much recent attention and may be appropriate in targeted, high-risk occupations. Although societal and other pressures often influence affected individuals not to seek assistance for substance abuse, employee assistance programs have proved to be exceptionally effective. Substance abuse should be considered a potential contributing factor to occupational trauma, and effective employee assistance programs should be made available nationwide.

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